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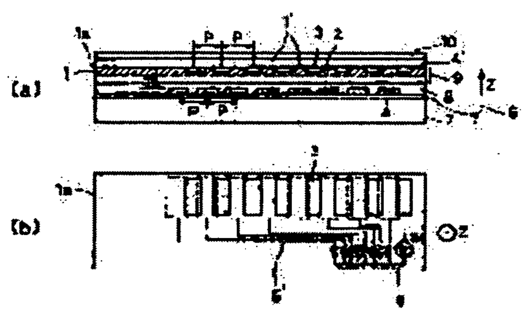
(54) OPTICAL SCANNING DEVICE



(57)Abstract:

PURPOSE: To obtain an optical scanning device which is an electro-optical deflection type and a has high efficiency and light resolving power.

CONSTITUTION: This optical scanning device which switches a forward path of light radiated in one direction to plural paths is provided with plural light waveguide members 3 which are provided linearly on the forward path of light radiated in one direction and constituted with materials in which light can transmits, plural electric field refraction members 1 which are provided alternately with the light waveguide members 3 on the forward path of light and in which a refractive index of forward light varies depending on existence of an electric field, when the electric field exists or not, a refractive index of forward light is equal or near to a refractive index of the light wave guide members, and when an electric field does not exist or exists, its refractive index is different from the refractive index of the light waveguide members 3, electrodes group 4 which is provided corresponding to each electric field refractive member 1, and a control circuit 5 which selectively applies the prescribed voltage to each electrode of the

electrodes group 4.

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CLAIMS

[Claim(s)]
[Claim 1] In the light-scanning equipment which changes the advance path of the beam of light discharged by the one direction with two or more paths Two or more optical waveguide members constituted by the quality of the material which it is linearly prepared in the advance path of the beam of light discharged in the direction of top Norikazu, and the above-mentioned light penetrates, It is prepared in the advance path of a beam of light the above-mentioned optical waveguide member and by turns, and the advancing rate of optical refraction by the existence of electric field It changes, and there are electric field or it becomes [whether when nothing it is equal to the refractive index of the above-mentioned optical waveguide member, and] near. That electric field are nothing or two or more electric-field refraction members which serve as a refractive index of the above-mentioned optical waveguide member, and a left refractive index when it is, Light-scanning equipment characterized by coming to provide the electrode group prepared corresponding to each above-mentioned electric-field refraction member, and the control circuit which impresses a predetermined electrical potential difference to each electrode of this electrode group alternatively.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the light-scanning equipment which changes the advance path of the beam of light discharged by one directions, such as a laser beam, in two or more directions, for example, relates to the light-scanning equipment in an image reader (scanner), a recording apparatus (laser beam printer), surface-analysis equipment, a display, etc.
[0002]
[Description of the Prior Art] It will be divided roughly into a mechanical scanner and a non-mechanical scanner if it classifies as above light-scanning equipments conventionally paying attention to the change means of a scanning direction. For example, although the scanner using the polygon mirror, GARUGANO meter, a hologram scanner, etc. as a mechanical scanner is known, in order that such a mechanical scanner may scan a beam of light by the mechanical movement toward rotation, vibration, etc. literally, a scan speed is limited remarkably. Moreover, it is difficult during a scan to stop a light beam in the location of arbitration, or to carry out light scanning in the mode of arbitration. For example, JP,62-212937,A is known. Then, in order to cancel the fault of these mechanical scanners, the non-mechanical scanner is proposed. For example, they are an acoustooptic deflector, a piezo scanner, heat optical deflecting system, an electrooptic deflector, etc. Drawing 6 (a) is an example of an acoustooptic deflector, and is the Ti diffusion LiNbO3. What was realized on waveguide is shown. The supersonic wave emitted from the transducer crosses a waveguide top, and makes the periodic roughness and fineness of a refractive index. thereby -- the Bragg diffraction -- being generated -- guided wave light -- diffraction -- that is, it deviates. If the frequency of a supersonic wave is changed, the pitch (wavelength) of roughness and fineness will change and the deviation direction will change. that the light-scanning equipment using such an acoustooptic deflector has a small deflection angle, and a deviation -- it is not put in practical use by the reason resolution is inadequate. A piezo scanner is not practical from the reason a deflecting angle is small. Heat optical deflecting system is a thing using the thermooptic effect from which a refractive index changes with temperature changes, and since heat is used for it, it has a fault with a slow

scan speed. An electrooptic deflector is the deflecting system using change (electro-optical effect) of the refractive index by the electric field of a ferroelectric, and drawing 6 (b) is the improved example. Drawing 6 (b) is $LiNbO_3$. It is the example realized using (LN) waveguide, and the principle of the Fresnel zone plate is used. That is, when the waveguide of LN crystal is prepared in the No. even zone and an electrical potential difference is not impressed, it is condensed by Point P, but if the phase of the light which impresses an electrical potential difference and passes the waveguide of each channel is controlled, it can condense at the point Q of arbitration. although this component has a quick scan speed compared with the above-mentioned deviation component and there are the advantages, such as having a condensing function, -- effectiveness and a deviation -- it is a fault that resolution is low. therefore, the effectiveness in a waveguide mold electrooptic deflector to which this invention described the target place above and a deviation -- it is offering the light-scanning equipment which aimed at improvement in resolution.

[0003]

[Means for Solving the Problem] In the light-scanning equipment with which this invention changes the advance path of the beam of light discharged by the one direction with two or more paths in order to attain the above-mentioned purpose Two or more optical waveguide members constituted by the quality of the material which it is linearly prepared in the advance path of the beam of light discharged in the direction of top Norikazu, and the above-mentioned light penetrates, It is prepared in the advance path of a beam of light the above-mentioned optical waveguide member and by turns, and the advancing rate of optical refraction by the existence of electric field It changes, and there are electric field or it becomes [whether when nothing it is equal to the refractive index of the above-mentioned optical waveguide member, and] near. That electric field are nothing or two or more electric-field refraction members which serve as a refractive index of the above-mentioned optical waveguide member, and a left refractive index when it is, It is constituted as light-scanning equipment characterized by coming to provide the electrode group prepared corresponding to each above-mentioned electric-field refraction member, and the control circuit which impresses a predetermined electrical potential difference to each electrode of this electrode group alternatively.

[0004]

[Function] The beam of light fired into the train of an optical waveguide member goes the inside of an optical waveguide member train straight on. Between the adjoining optical waveguide members, the electric-field refraction member is prepared by turns, and by changing the electric field to these electric-field refraction members by the control circuit, light strays off a rectilinear-propagation path in the plane of composition of the electric-field refraction member and photoconductive wave member to which electric field were applied, and it refracts and goes on in the predetermined direction. Therefore, if the electric-field refraction member to which electric field were given is changed one by one by the above-mentioned control circuit, the electric-field refraction member by which the above-mentioned refraction multiplies can be changed, and the candidate for detection which counters this can be scanned.

[0005]

[Example] Then, with reference to the attached drawing, it explains per [which materialized this invention] example, and an understanding of this invention is presented. It is the sectional view in which drawing in which drawing 1 is drawing showing the concept of the light-scanning equipment concerning one example of this invention, and drawing 2 shows an operation of the light scanning, drawing in which drawing 3 shows the example of a configuration of the optical waveguide member of this light-scanning equipment, drawing in which drawing 4 shows the example of arrangement of this optical waveguide member, and drawing 5 show other examples of this invention here. First, with reference to drawing 1 , the procedure of manufacturing the waveguide mold light-scanning component 6 which is one example of this invention is explained.

(1) It is Si first. It is SiO_2 on a substrate 7. Layer 7' is formed.

(2) Next, the above SiO_2 aluminum electrode group 4 and circuit pattern 5' are vapor-deposited in a pitch p on layer 7'.

(3) Above SiO_2 Layer 7' and aluminum electrode group 4 are covered by the buffer layer 8 of magnesium fluoride MgF_2.

(4) On the above-mentioned buffer layer 8, it is $LiNbO_3$ by the reactant direct-current magnetron sputtering method. A layer 9 is formed so that a substrate and a crystallographic axis (Z-axis) may cross at right angles.

(5) Above $LiNbO_3$ Ti is made to adhere in a spatter on a layer 9, and it is N_2 [1000-degree C]. It heats in an ambient

atmosphere for about 10 hours. Thereby, it is LiNbO3. Thermal diffusion of Ti is carried out to the surface of a layer 9, and a slab waveguide 1 is formed.

(6) On the above-mentioned slab waveguide 1, apply a photoresist, carry out wet etching using dry etching or a fluorine acid system solution, and form the periodic depression group 2 of a pitch p. The above-mentioned depression group 2 is formed between the adjoining aluminum electrodes 4.

(7) It is Nb1+XO 3-x to the above-mentioned periodic depression group 2. It is made to deposit and they are Nb1+XO(s) 3-x other than the account of Gokami periodic depression group 2. The periodic depression group 2 is filled up with an optical material 3 (Nb1+XO 3-x) (optical waveguide member) by removing. Therefore, the part (it counters with the aluminum electrode 4) of the slab waveguide 1 inserted among the adjoining above-mentioned optical materials 3 and 3 constitutes electric-field refraction member 1'. However, the above-mentioned chemistry theory-presentation ratio X is adjusted so that it may agree in the refractive index n0 (it changes also with the concentration of Ti which is about 2.2 and is diffused in the refractive index to an extraordinary ray) of the slab waveguide 1 (electric-field refraction member 1') in case the refractive indexes n1 of the above-mentioned optical material 3 (Nb1+XO 3-x) are non-electric field.

(8) Then, create ITO (I; indium, T; tin, O; oxygen) transparent electrode 4' in a top face.

(9) Carry out bonding of above-mentioned circuit pattern 5' and transparent electrode 4' to the electrical-potential-difference drive switch circuit 5 (control circuit). In this case, above-mentioned transparent electrode 4' is made into a ground side.

(10) Cover above-mentioned ITO transparent electrode 4' and circuit pattern 5' with the insulating protective coat 10 of transparence.

[0006] One end-face 1a of the slab waveguide 1 created in the above-mentioned procedure The light-scanning actuation which changes the path of the beam of light introduced into the above-mentioned slab waveguide 1 is explained using drawing 2 .

a) When not impressing an electrical potential difference to aluminum electrode group 4. n1 n0. Since it is equal, for beams of light, such as a guided wave laser beam, the optical material 3 of the periodic depression group 2 does not appear on a slab waveguide 1, but a beam of light goes the inside of a slab waveguide 1 straight on (it passes).

b) When the predetermined electrical potential difference V is impressed to any one or more aluminum electrodes 4 among aluminum electrode groups 4. If distance of aluminum electrode group 4 and transparent electrode 4' is set to d, electric-field E=V/d will start electric-field refraction member 1' of a slab waveguide 1, and an optical material 3 (Nb1+XO 3-x) by impression of the above-mentioned electrical potential difference V. For the above-mentioned optical material 3, since it does not have the electro-optical effect, the refractive index is n1. Although it is as, since electric-field refraction member 1' of a slab waveguide 1 has the electro-optical effect, as for a refractive index, only deltan of a degree type changes.

deltan=(1/2) r33, n0, and E -- (1)

It is the electro-optic constant which contributes to Z shaft orientations here when r33 applies electric field to Z shaft orientations of a slab waveguide 1. Therefore, a refractive-index difference arises in the interior and the exterior of the periodic depression 2 of a field to which electric field were applied, and dispersion of guided wave light takes place by the interface of the depression section 2. Here, if the pitch of the electrode which impresses an electrical potential difference is fixed, the scattered light (Huygens's ******) from a field side will be diffracted in the direction which had a phase to each other. Change deltan of a refractive index is 1.6x10 to about three, even when micrometer is impressed in 10v /a little smaller than the limitation of bringing about dielectric breakdown of a crystal as electric field (V=30V, t= 3 micrometers), and the permeability T on the strength [optical] in one interface follows Fresnel's transmission method rule. T= {(2n0) /(2n0+deltan)} 2 = 0.999273 -- (2)

, -- although dispersion is very slight to 1 soon, if the pitch of the periodic depression section 2 is set to 1 micrometer and an electrical potential difference is impressed to 2000 depressions covering the 2mm of the directions of a guided wave, since dispersion mostly given by the formula (2) in the both ends of a depression will take place and 4000 interfaces will arise T40000.05 -- (3)

A next door and about 95% of quantity of light will be diffracted.

[0007] As stated above, in the above-mentioned example, the parallel displacement of the deviation location can be carried out by impressing an electrical potential difference to an electrode 4 alternatively. A light-scanning component

can be obtained by this and the resolving power of the parallel translation is decided in an electrode pitch. Moreover, the deflection angle is adjusted by changing the pitch p of the electrode 4 which impresses an electrical potential difference. Therefore, it is possible to be alike, if the pitch p of the above-mentioned electrode 4 is changed into **** as shown in drawing 2 (c), and to also make one point P condense the scattered light from the depression section 2 of eye the k-th k+n watch [-] more. The above condensing is possible also by changing the magnitude of the electrical potential difference given to an electrode to ****. In the above-mentioned example, aluminum electrode group 4 and the periodic depression group 2 are formed in the direction which intersects perpendicularly in the direction of a guided wave band-like [linear], as shown in drawing 1 (b), but in order to heighten above-mentioned condensing effectiveness, they may be formed in band-like [of circular or an ellipse] like drawing 3 . Moreover, as said aluminum electrode group 4 and the periodic depression group 2 are shown in drawing 4 , it is possible by carrying out two-dimensional array in a grid pattern to enable two-dimensional selection of an electrode and to also make one point of the space besides a slab waveguide 1 condense. LiNbO3 which diffused Ti in the above-mentioned example when not impressing an electrical potential difference It is LiNbO3 if it suits in the precision of 10-3, although the refractive index of the optical material 3 (ND1+XO 3-x) with which was dented with the refractive index and the section 2 was filled up was made strictly in agreement. Since the electro-optical effect is bidirection, it is possible by giving bias voltage suitably to also make both refractive index agree. Moreover, in the above-mentioned example, although the slab waveguide 1 (two-dimensional waveguide) was used, channel waveguide (1-dimensional waveguide) can also be used. In addition, at the above-mentioned example, it is the Ti diffusion LiNbO3 about a slab waveguide 1. Although it created, the electro-optical effect was given and the optical material 3 (ND1+XO 3-x) without the electro-optical effect was used for the interior of the periodic depression group 2 As shown in drawing 5 , a step mold (it consists of a substrate with a low refractive index a guided wave side with a high refractive index) may constitute slab waveguide 1' from an optical material without the electro-optical effect, periodic depression group 2' may be formed in the front face, and deposition of optical material 3' with the electro-optical effect may be formed.
[0008]
[Effect of the Invention] since this invention is constituted as stated above -- effectiveness -- high -- a deviation -- light-scanning equipment with high resolution can be offered.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Drawing showing the concept of the light-scanning equipment concerning one example of this invention.
[Drawing 2] Drawing showing an operation of the light scanning.
[Drawing 3] Drawing showing the example of a configuration of the optical waveguide member of this light-scanning equipment.
[Drawing 4] Drawing showing the example of arrangement of this optical waveguide member.
[Drawing 5] The sectional view showing other examples of this invention.
[Drawing 6] The conceptual diagram of conventional light-scanning equipment.
[Description of Notations]
1 -- Slab waveguide 1' -- Electric-field refraction member
4 -- aluminum electrode group (electrode group) 5 -- Electrical-potential-difference drive switch circuit (control circuit)
2 -- Periodic depression section 3 -- Optical member (optical waveguide member)
6 -- Waveguide mold light-scanning equipment 7 -- Si substrate
8 -- Buffer layer

[Translation done.]

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審査請求　未請求　請求項の数１（全　５　頁）

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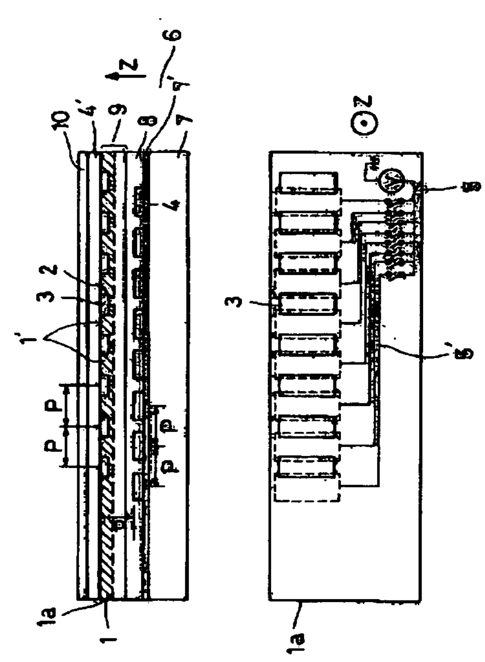
(54)【発明の名称】　光走査装置

(57)【要約】

【目的】　電気光学偏向型の光走査装置で，効率，光分解能の高い光走査装置を提供する。

【構成】　一方向に発射された光線の進行経路を複数の経路に切りかえる光走査装置において，上記一方向に発射された光線の進行経路に直線的に設けられ，上記光が透過する材質により構成された複数の光導波路部材と，上記光導波路部材と交互に光線の進行経路に設けられ，進行する光の屈折率が電場の有無により変化し，電場が有り又は無しの時上記光導波路部材の屈折率と等しいか近くなり，電場が無し又は有りの時上記光導波路部材の屈折率と離れた屈折率となる複数の電場屈折部材と，上記各電場屈折部材に対応して設けられた電極群と，該電極群の各電極に所定電圧を選択的に印加する制御回路とを具備してなることを特徴とする光走査装置。



(a)
(b)

【特許請求の範囲】

【請求項１】　一方向に発射された光線の進行経路を複数の経路に切りかえる光走査装置において，上記一方向に発射された光線の進行経路に直線的に設けられ，上記光が透過する材質により構成された複数の光導波路部材と，上記光導波路部材と交互に光線の進行経路に設けられ，進行する光の屈折率が電場の有無により変化し，電場が有り又は無しの時上記光導波路部材の屈折率と等しいか近くなり，電場が無し又は有りの時上記光導波路部材の屈折率と離れた屈折率となる複数の電場屈折部材と，上記各電場屈折部材に対応して設けられた電極群と，該電極群の各電極に所定電圧を選択的に印加する制御回路とを具備してなることを特徴とする光走査装置。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は，レーザビーム等の一方向に発射された光線の進行経路を複数の方向に切りかえる光走査装置に係り，例えば，画像読み取り装置（スキャナ），記録装置（レーザビームプリンタ），表面検査装置，表示装置等における光走査装置に関するものである。

【０００２】

【従来の技術】従来，上記のような光走査装置として，走査方向の切りかえ手段に着目して分類すると，機械式走査装置と非機械式走査装置とに大別される。機械式走査装置としては，例えば，ポリゴンミラーやガルガノメーター，ホログラムスキャナ等を用いた走査装置が知られているが，このような機械式走査装置は文字通り回転や振動等の機械的動きによって光線の走査を行うため，走査速度は著しく限定される。また，走査中に任意の位置で光ビームを止めたり，任意の態様で光走査をすることが困難である。例えば，特開昭６２－２１２９３７号公報が知られている。そこで，これらの機械式走査装置の欠点を解消するために，非機械式走査装置が提案されている。例えば，音響光学偏向器，ピエゾスキャナ，熱光学偏向器，電気光学偏向器等である。図６（ａ）は音響光学偏向器の一例であり，Ｔｉ拡散ＬｉＮｂＯ$_3$導波路上で実現したものを示す。トランスジューサから発した超音波は，導波路上を横断し，屈折率の周期的粗密を作る。それによりブラッグ回折が生じ，導波光が回折，即ち，偏向される。超音波の周波数を変えると粗密のピッチ（波長）が変わり，偏向方向が変わる。このような音響光学偏向器を用いた光走査装置は，偏向角が小さいこと及び偏向分解能が不十分であるといった理由により実用化されていない。ピエゾスキャナは，偏向角度が小さいという理由から実用的でない。熱光学偏向器は，温度変化により屈折率が変化する熱光学効果を用いたもので，熱を用いることから走査速度が遅い欠点がある。電気光学偏向器は，強誘電体の電場による屈折率の変化（電気光学効果）を利用した偏向器で，図６（ｂ）はその改良された一例である。図６（ｂ）はＬｉＮｂＯ$_3$（ＬＮ）導波路を用いて実現した例で，フレネルゾーンプレートの原理を利用している。即ち，偶数番ゾーンにはＬＮ結晶の導波路が設けられており，電圧を印加しないときには点Ｐに集光されるが，電圧を印加し各チャンネルの導波路を通過する光の位相を制御すれば，任意の点Ｑに集光できる。この素子は，前述の偏向素子に比べて走査速度が速く，集光機能を持つ等の長所があるが，効率，偏向分解能の低いことが欠点である。従って，本発明が目的とするところは，上記したような導波路型電気光学偏向器における効率，偏向分解能の向上を図った光走査装置を提供することである。

【０００３】

【課題を解決するための手段】上記目的を達成するために，本発明は，一方向に発射された光線の進行経路を複数の経路に切りかえる光走査装置において，上記一方向に発射された光線の進行経路に直線的に設けられ，上記光が透過する材質により構成された複数の光導波路部材と，上記光導波路部材と交互に光線の進行経路に設けられ，進行する光の屈折率が電場の有無により変化し，電場が有り又は無しの時上記光導波路部材の屈折率と等しいか近くなり，電場が無し又は有りの時上記光導波路部材の屈折率と離れた屈折率となる複数の電場屈折部材と，上記各電場屈折部材に対応して設けられた電極群と，該電極群の各電極に所定電圧を選択的に印加する制御回路とを具備してなることを特徴とする光走査装置として構成されている。

【０００４】

【作用】光導波路部材の列に撃ち込まれた光線は，光導波路部材列内を直進する。隣接する光導波路部材の間には交互に電場屈折部材が設けられており，これらの電場屈折部材に対する電場を，制御回路により切りかえることにより，電場のかけられた電場屈折部材と光導波部材との接合面で光が直進経路から外れて所定方向に屈折して進行する。従って，上記制御回路により，電場の与えられた電場屈折部材を順次切りかえれば，上記屈折の乗じる電場屈折部材を切りかえることができ，これに対向する検出対象を走査することができる。

【０００５】

【実施例】続いて，添付した図面を参照して，本発明を具体化した実施例につき説明し，本発明の理解に供する。ここに，図１は本発明の一実施例に係る光走査装置の概念を示す図であり，図２はその光走査の作用を示す図，図３は同光走査装置の光導波路部材の形状例を示す図，図４は同光導波路部材の配置例を示す図，図５は本発明の他の実施例を示す断面図である。先ず，図１を参照して，本発明の一実施例である導波路型光走査素子６を製造する手順を説明する。

（１）先ず，Ｓ$_1$基板７上にＳｉＯ$_2$層７′を形成する。

（２）次に，上記SiO_2層７′上にピッチｐでＡｌ電極群４及び配線パターン５′を蒸着する。

（３）上記SiO_2層７′及びＡｌ電極群４を，フッ化マグネシウムMgF_2のバッファ層８で覆う。

（４）上記バッファ層８の上に，反応性直流マグネトロンスパッタ法により，$LiNbO_3$層９を結晶軸（Ｚ軸）が基板に直交するように形成する。

（５）上記$LiNbO_3$層９上にＴｉをスパッタで付着させ，１０００℃のN_2雰囲気で約１０時間加熱する。これにより，$LiNbO_3$層９の表層にＴｉを熱拡散させ，スラブ導波路１を形成する。

（６）上記スラブ導波路１上にフォトレジストを塗布し，ドライエッチング又はフッ素酸系溶液を用いてウェットエッチングをして，ピッチｐの周期的凹み群２を形成する。上記凹み群２は隣接するＡｌ電極４の間に形成される。

（７）上記周期的凹み群２に対して，$Nb_{1+x}O_{3-x}$を堆積させ，その後上記周期的凹み群２以外の$Nb_{1+x}O_{3-x}$を除去することにより，周期的凹み群２に光学材料３（$Nb_{1+x}O_{3-x}$）（光導波路部材）を充填する。従って隣接する上記光学材料３，３の間にはさまれたスラブ導波路１の部分（Ａｌ電極４と対向する）が電場屈折部材１′を構成する。但し，上記化学論的組成比Ｘは上記光学材料３（$N_{b1+x}O_{3-x}$）の屈折率n_1が無電場のときのスラブ導波路１（電場屈折部材１′）の屈折率n_0（異常光線に対する屈折率で２．２程度であり，拡散＊

＊させるＴｉの濃度によっても変わる）に合致するように調節されている。

（８）続いて，上面にＩＴＯ（Ｉ；インジウム，Ｔ；錫，Ｏ；酸素）透明電極４′を作成する。

（９）上記配線パターン５′及び透明電極４′を電圧駆動切り換え回路５（制御回路）にボンディングする。この場合，上記透明電極４′をアース側とする。

（１０）上記ＩＴＯ透明電極４′及び配線パターン５′を透明の絶縁保護膜１０で被覆する。

【０００６】上記の手順で作成されたスラブ導波路１の一方の端面1_aより，上記スラブ導波路１に導入された光線の経路を切りかえる光走査動作を，図２を用いて説明する。

ａ）Ａｌ電極群４に電圧を印加しないとき。n_1とn_0が等しいため，導波レーザ光等の光線にとってスラブ導波路１上に周期的凹み群２の光学材料３が見えず，光線はスラブ導波路１内を直進する（通り抜ける）。

ｂ）Ａｌ電極群４のうち，いずれか一つ以上のＡｌ電極４に所定の電圧Ｖを印加したとき。Ａｌ電極群４と透明電極４′との距離をｄとすると，上記電圧Ｖの印加によって，電場Ｅ＝Ｖ／ｄがスラブ導波路１の電場屈折部材１′及び光学材料３（$Nb_{1+x}O_{3-x}$）にかかる。上記光学材料３は電気光学効果を持たないので，その屈折率はn_1のままであるが，スラブ導波路１の電場屈折部材１′は電気光学効果を有するので，屈折率は次式のΔｎだけ変化する。

$$\Delta n = (1/2)\, r_{33} \cdot n_0 \cdot E \quad \cdots (1)$$

ここに，r_{33}はスラブ導波路１のＺ軸方向に電場をかけたときにＺ軸方向に寄与する電気光学定数である。従って，電場をかけた領域の周期的凹み２の内部と外部で屈折率差が生じ，凹み部２の界面で導波光の散乱が起こる。もしここで，電圧を印加する電極のピッチが一定であれば，各界面からの散乱光（ホイヘンスの素源波）は※

※おたがいに位相があった方向に回折されることになる。屈折率の変化Δｎは，電場として結晶の絶縁破壊をもたらす限界よりやや小さい１０Ｖ／μｍを印加したとき（Ｖ＝３０Ｖ，ｔ＝３μｍ）でも1.6×10^{-3}程度であり，１界面での光強度透過率Ｔはフレネルの透過法則に従って，

$$T = \{(2n_0)/(2n_0+\Delta n)\}^2 = 0.999273 \quad \cdots (2)$$

と，極めて１に近く散乱は僅かであるが，周期的凹み部２のピッチを１μｍとし，導波方向２ｍｍにわたって２０００個の凹みに電圧を印加すれば，凹みの両端でほぼ★

★式（２）で与えられる散乱が起こり，４０００界面が生じるから，

$$T^{4000} \fallingdotseq 0.05 \quad \cdots (3)$$

となり，約９５％の光量が回折されることになる。

【０００７】以上述べたように，上記実施例では，電極４に選択的に電圧を印加することにより，偏向位置を平行移動させることができる。これにより光走査素子を得ることができ，その平行移動の分解能は電極ピッチで決められる。また，その偏向角は，電圧を印加する電極４のピッチｐを変えることにより調整される。従って図２（ｃ）に示す如く，上記電極４のピッチｐを除々に変えるとによりｋ番目〜ｋ＋ｎ番目の凹み部２からの散乱光を１点Ｐに集光させることも可能である。上記のような集光は電極に与える電圧の大きさを除々に変化させることによっても可能である。上述の実施例では，Ａｌ電極群４及び周期的凹み群２は，図１（ｂ）に示す如く導波方向に直交する方向に直線の帯状に形成されているが，上述の集光効果を高めるために，円形又は楕円の帯状に，図３の如く，形成してもよい。また，前記Ａｌ電極群４及び周期的凹み群２を，図４に示す如く，碁盤目状に２次元配列させることにより，電極の２次元的選択を可能とし，スラブ導波路１外の空間中の一点に集光させることも可能である。上記の実施例では，電圧を印加しないとき，Ｔｉを拡散させた$LiNbO_3$の屈折率と凹み部２に充填した光学材料３（$N_{b1+x}O_{3-x}$）の屈折率とを厳密に一致させたが，10^{-3}の精度で合っておれば$LiNbO_3$の電気光学効果は双方向性であるので，バ

イアス電圧を適当に与えることによって両者の屈折率を合致させることも可能である。また，上記の実施例では，スラブ導波路１（２次元導波路）を用いたが，チャンネル導波路（１次元導波路）を用いることもできる。なお，上記実施例では，スラブ導波路１をＴｉ拡散ＬｉＮｂ$\mathrm{O_3}$により作成し，電気光学効果を持たせ，周期的凹み群２の内部には電気光学効果を持たない光学材料３（$\mathrm{N_{b1+x}O_{3-x}}$）を用いたが，図５に示す如く，スラブ導波路１´を電気光学効果を持たない光学材料でステップ型（屈折率の高い導波側と屈折率の低い基板からなる）で構成し，その表面に周期的凹み群２´を形成し，電気光学効果のある光学材料３´の堆積を形成してもよい。

【０００８】

【発明の効果】本発明は，以上述べた如く構成されているので，効率が高く，偏向分解能の高い光走査装置を提供することができる。　＊

＊【図面の簡単な説明】

【図１】　本発明の一実施例に係る光走査装置の概念を示す図。

【図２】　その光走査の作用を示す図。

【図３】　同光走査装置の光導波路部材の形状例を示す図。

【図４】　同光導波路部材の配置例を示す図。

【図５】　本発明の他の実施例を示す断面図。

【図６】　従来の光走査装置の概念図。

【符号の説明】

１…スラブ導波路　　１´…電場屈折部材

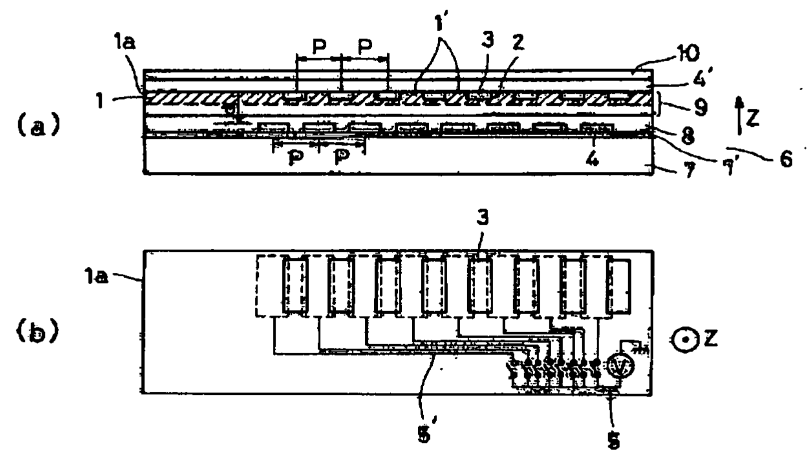
４…Ａｌ電極群（電極群）　　５…電圧駆動切り換え回路（制御回路）

２…周期的凹み部　　３…光学部材（光導波路部材）

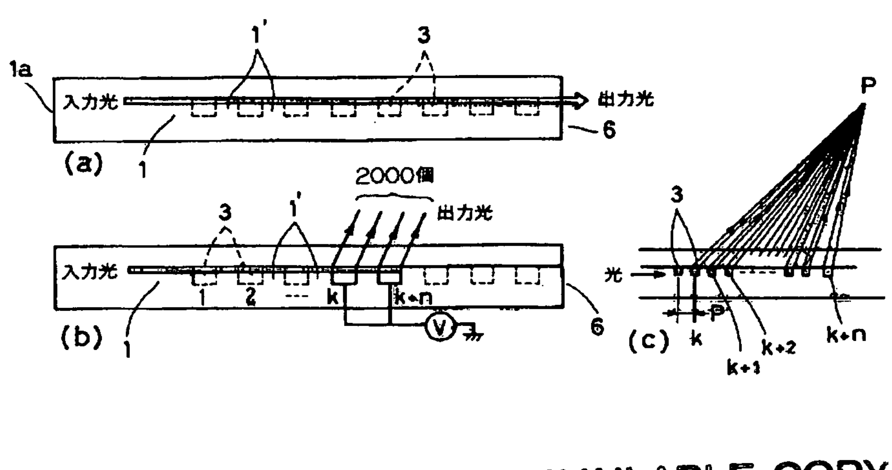
６…導波路型光走査装置　　７…Ｓｉ基板

８…バッファ層

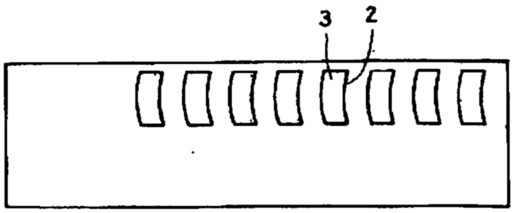
【図１】



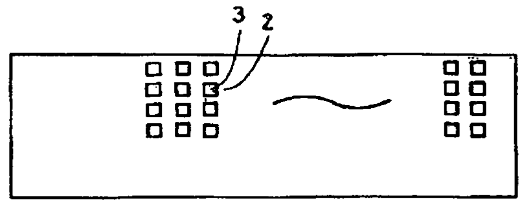
【図２】



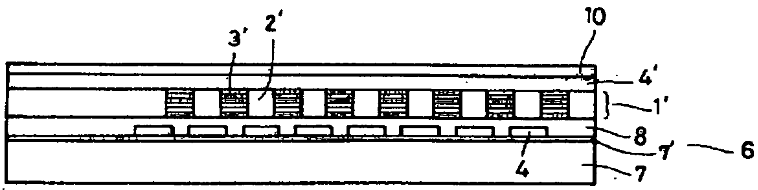
【図3】


3
2

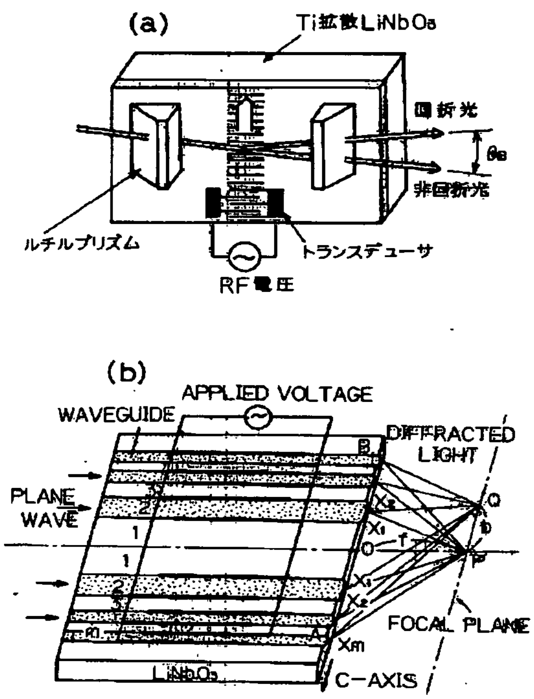
【図4】


3
2

【図5】


10
3'
2'
4'
1'
8
7'
6
4
7

【図6】


(a)
Ti拡散LiNbO3
回折光
θB
非回折光
ルチルプリズム
トランスデューサ
RF電圧
(b)
APPLIED VOLTAGE
WAVEGUIDE
DIFFRACTED LIGHT
PLANE WAVE
FOCAL PLANE
LiNbO3
C-AXIS